ESTIMATES OF WATER CONTENT IN THE ATMOSPHERE OF VENUS ACCORDING TO DATA FROM RADIO-ASTRONOMICAL MEASUREMENTS AND SPACE PROBES

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16. Abstract

The article presents data on the water content of the atmosphere of Venus. The data was collected from radioastronomical measurements and also from space probes, such as "Venera-4", using the Ho-Kaufman-Thaddeus formula and Staelin's relation to determine absorption spectra in the superhigh frequency zone for constituent absorptions in the carbon dioxide gas, water vapor, and in the cloud cover.

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ESTIMATES OF WATER CONTENT IN THE ATMOSPHERE OF VENUS ACCORDING TO DATA FROM RADIO-ASTRONOMICAL MEASUREMENTS AND SPACE PROBES

A. Ye. Basharinov and B.G. Kutuza

1. The question concerning the water content in the atmosphere of Venus is of considerable interest for the theory of processes of thermal conductivity, the processes of transfer of microwave radiation, for estimates of the possibilities for radiometrical thermal sounding, and others. /375*

The data of the space probe "Venera-4" point to carbon dioxide as the basic component of the atmosphere. According to the data of spectroscopic estimates, the relative content of water vapor above the cloud layer does not exceed 0.01% [1,2]; according to the measurements of "Venera-4" this value comprises 0.1-0.7% [4,6].

In order to estimate the limits of the values of moisture contents in the liquid phase and their influence on the form of the spectrum of radio-luminance temperatures we will consider two models of the atmosphere, constructed by taking account of the data of space probes and radio-astronomical observations [2,3,4,9].

For the first model (called, by convention, equatorial) the pressure and temperature at the surface are assumed to be p_0 = 30 atm., and T_0 = 600° K, respectively. The vertical temperature gradient dT/dH = 9 degrees/km. The height of the homogeneous atmosphere H_0 = 12 km.

For the second model, the conditions required for reflection in the polar regions, the surface pressure and temperature are assumed to be p_0 = 30 atm. and T_0 = 450° K.

2. Estimates of the water content in the liquid phase are derived by means of a determination of the condensation zones where

*Numbers in the margin indicate pagination in the foreign text.

the partial pressure of the water vapor exceeds the pressure of the saturated vapors.

In Figure 1-a, upper atmosphere variations of the pressure of the saturated vapors on the water are represented in a system of coordinates proposed by A. M. Obukhov and G. S. Golitsyn [6], and the condensation zones are plotted.

The specific content of moisture in the liquid phase (water content) is detemined by the difference of the values of the partial pressure of the water vapor e = fp and the pressure of the saturated vapor E.

$$W = \frac{\mu_{H_2O}}{RT}(f_{H_2O}p - E). \qquad (1)$$

The upper-atmosphere dependencies of the water content of clouds are depicted in Figure 1-b.

The estimates of the values of the integral content of moisture in the liquid phase, W_Σ, of the vapor phase ρ_Σ, and the thickness of the cloud layer for the equatorial and polar models are presented in the table.

	$f_{H_2O} = 0.1\%$			$f_{H_2O} = 0.7\%$		
	ρ_Σ, $\frac{g}{cm^2}$	W_Σ, $\frac{g}{cm^2}$	ΔH, km	ρ_Σ $\frac{g}{cm^2}$	W_Σ $\frac{g}{cm^2}$	ΔH, km
Model 1	30	0.03	3	200	0.3	6
Model 2	30	1.00	5	200	7.0	15

The relatively small amount of the water supply in the liquid phase in the regions ($W_\Sigma/\rho_\Sigma \sim 10^{-3}$-$10^{-2}$) and the sharp increase of the thickness of clouds in the polar regions are noteworthy.

3. The presence of water vapor in the atmosphere of Venus influences the absorption spectrum of superhigh frequency

oscillations and the spectrum of radio-brightness of the planet.

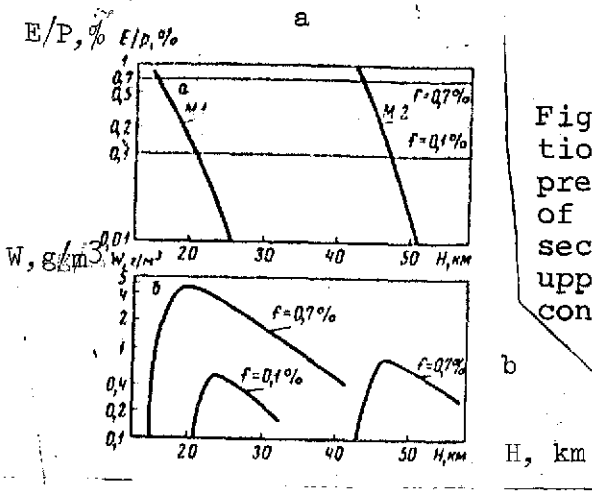

Figure 1. Upper-atmosphere relations of the partial pressure and pressure of saturated molecules of water for the first (M1) and second (M2) models (a), and the upper atmosphere profiles of water content in the clouds (b).

The absorption spectrum in the superhigh frequency zone is primarily determined by the constituent absorptions in the carbon dioxide gas, water vapor, and in the cloud cover. /376

The absorption in the carbon dioxide gas is estimated by the formula of Ho, Kaufman, and Thaddeus [7]

$$\gamma_{CO_2}\left[\frac{1}{\text{см}}\right] = 15{,}7\cdot 10^{-7}\,\frac{p^2\nu^3}{c^4}\left(\frac{273}{T}\right)^5 f_{CO_2}. \qquad (2)$$

The relation of Staelin [8], corrected in conformity with the carbon dioxide atmosphere, and the Ho-Kaufman-Thaddeus relation are used for estimating the absorption in the water vapor:

$$\gamma_{H_2O}\left[\frac{1}{\text{см}}\right] = 1330\cdot 10^{-7}\,\frac{p^2\nu^2}{c^3}\left(\frac{273}{T}\right)^5 f_{H_2O}. \qquad (3)$$

For the carbon dioxide atmosphere, correspondingly, the Staelin relation has the form

$$\gamma_{H_2O}\left[\frac{1}{\text{см}}\right] = 2{,}55\cdot 10^{-8}\rho_{H_2O}\,\frac{\Delta\nu_{CO_2}}{T^{3/2}}, \qquad (4)$$

where

$$\Delta\nu_{CO_2} = A_1\left(1 + \frac{A_2 p_{H_2O} T}{p}\right),$$

A_1 and A_2 are coefficients depending on the magnitudes of the cross section of the molecular collision in the carbon dioxide medium. The estimates of absorption in the water vapor according to formulas (3) and (4) showed a noticeable divergence; one can propose that (3) gives the lower estimate, and (4) the upper estimate.

The absorption in a drop of moisture is estimated according to the formula

$$\gamma_0(\lambda, T) = kW \frac{\varepsilon_i(\lambda, T)}{[\varepsilon_r(\lambda, T) + 2]^2 + \varepsilon_i^2(\lambda, T)}, \quad (5)$$

where $\varepsilon_r(\lambda,T)$ and $\varepsilon_i(\lambda,T)$ are the values of the real and imaginary parts of the permeability of water. The spectra of radio-brightness of Venus, calculated by an integral of radiation transfer for the chosen models in a layered approximation for a layer thickness of 2 km, taking account of the vertical distribution of water in the clouds according to Figure 1, are depicted in Figure 2.

The influence of absorption in vapor and liquid moisture causes a shift of the oblique portion of the spectrum to the region of longer waves and is accompanied by a change of the radio-brightness up to 100° K.

A comparison of the calculated spectra with the data of radio- /377
astronomical observations shows a satisfactory agreement, when averaging along a scale of values the moisture contents not greater than 0.3%.

Variations of the radio-brightness spectrum due to the change in the moisture content are accompanied by a change of the

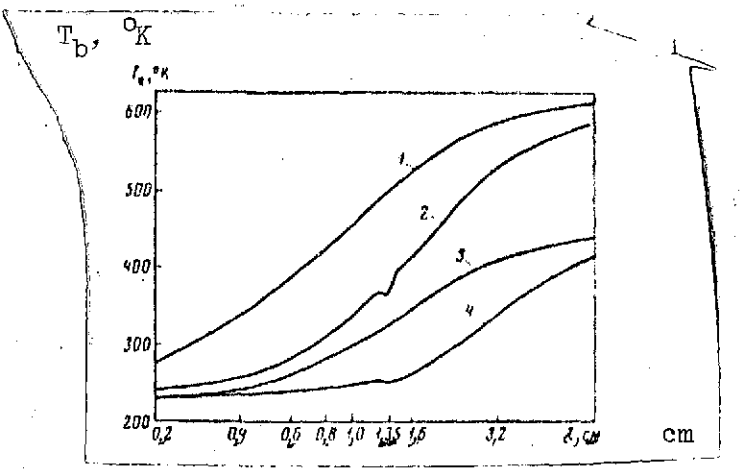

Figure 2. Spectra of radio-brightness for models of the atmosphere of Venus.
1- equatorial model $f_{H_2O} = 0$;
2- the same, $f_{H_2O} = 0.7\%$;
3- polar model, $f_{H_2O} = 0$;
4- the same, $f_{H_2O} = 0.7\%$.

depths of the effective radiating layers, which limits the accuracy of the upper atmospheric survey of the temperature during radiometric thermal soundings.

According to the data presented in Figure 2, the variations of the altitudes of the effectively radiating layers for a change of the moisture content from 0 to 0.7% reach 10 km; for a change of moisture content within the limits of 0.3%, the variations of the altitude of the effectively radiating layers do not exceed 3-4 km.

Obtaining data on the vertical distribution of moisture content is of considerable importance for understanding the nature of water vapors in the atmosphere.

REFERENCES

1. H. Spinrad, Publ. Astr. Soc. Pac., 74, 187, 62.
2. V. I. Moroz. Fizika Planet [Physics of the Planets], "Nauka Press", 1967.
3. A. D. Kuz'min, B. Dzh. Klark. Astron. Zh., 42, 3, 595, 1965.
4. V. I. Moroz, V. G. Kurm, Kosmicheskiye issledovaniya, 6, 4, 1968.
5. A. D. Kuz'min, Yu. N. Vetukhnovskaya, Kosmicheskiye issledovaniya, 6, 4, 1968.
6. A. M. Obukhov, G. S. Golitsyn, Kosmicheskiye issledovaniya, 6, 5, 1968.
7. W. Ho, I. Kaufman, P. Thaddeus, J. Geoph. Res., 71, 12, 1966.
8. D. Staelin, J. Geoph. Res., 71, 12, 1966.
9. V. S. Avduyevskiy, N. Ya. Marov, V. V. Mikhnevich, Doklad na XI Kongressov KOSPAR [Report to the XI Congress of COSPAR], Tokyo, 1968.